Sept. 28, 1965 J. F. TAPLIN 3,208,394

PISTON PUMP HAVING ROLLING DIAPHRAGM AND PRESSURE EQUALIZATION MEANS

Filed June 30, 1964 3 Sheets-Sheet 1

Fig. 2.

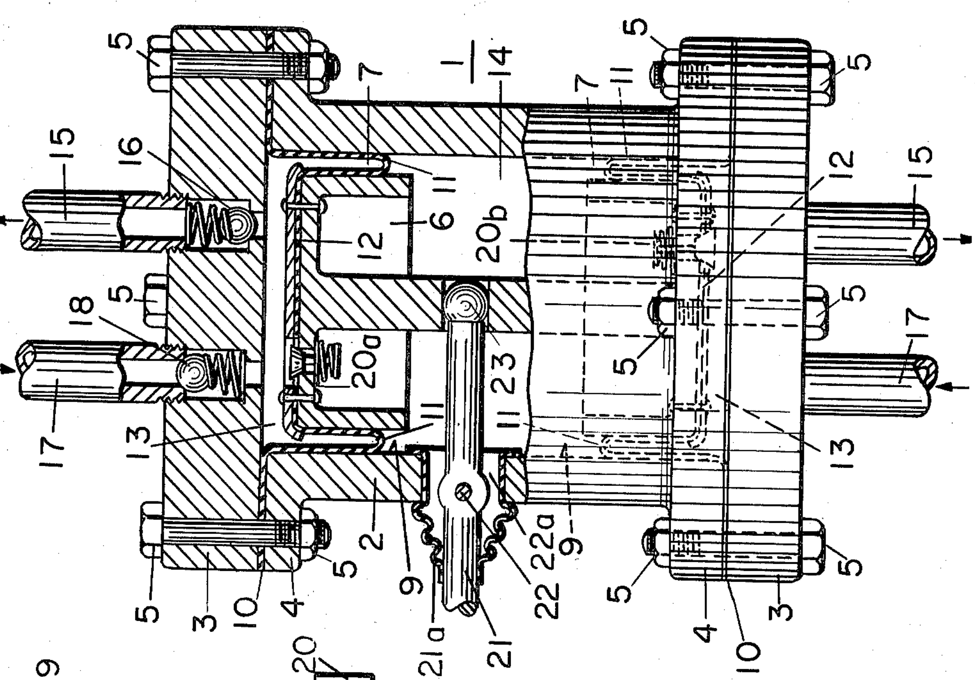

Fig. 1.

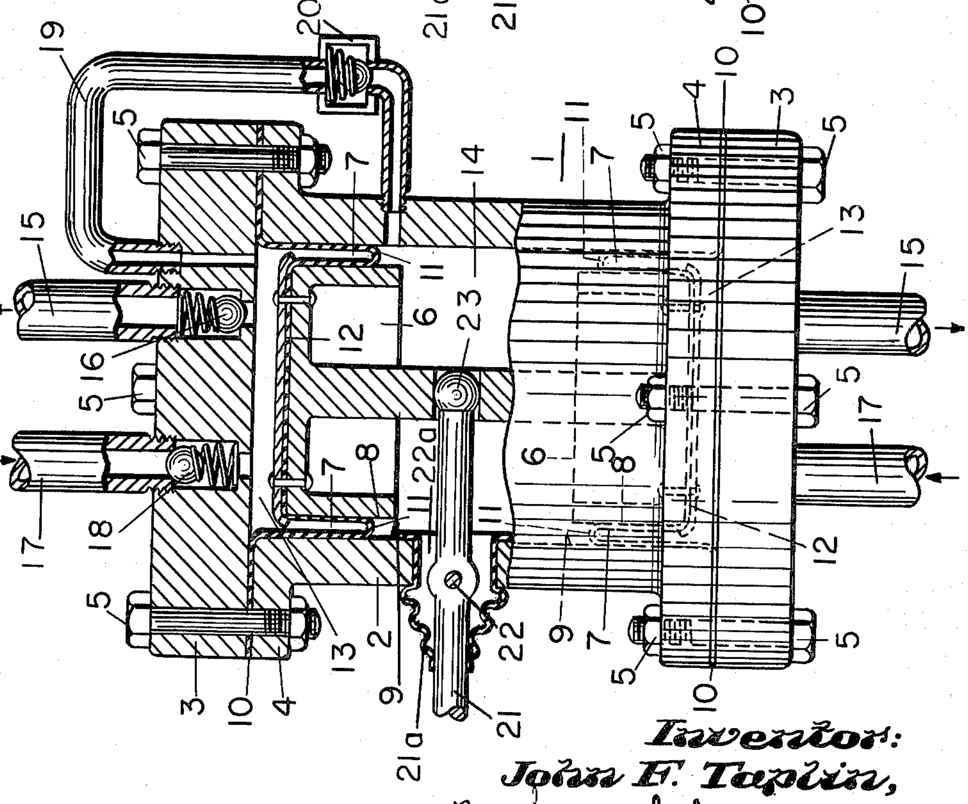

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Fig. 3.

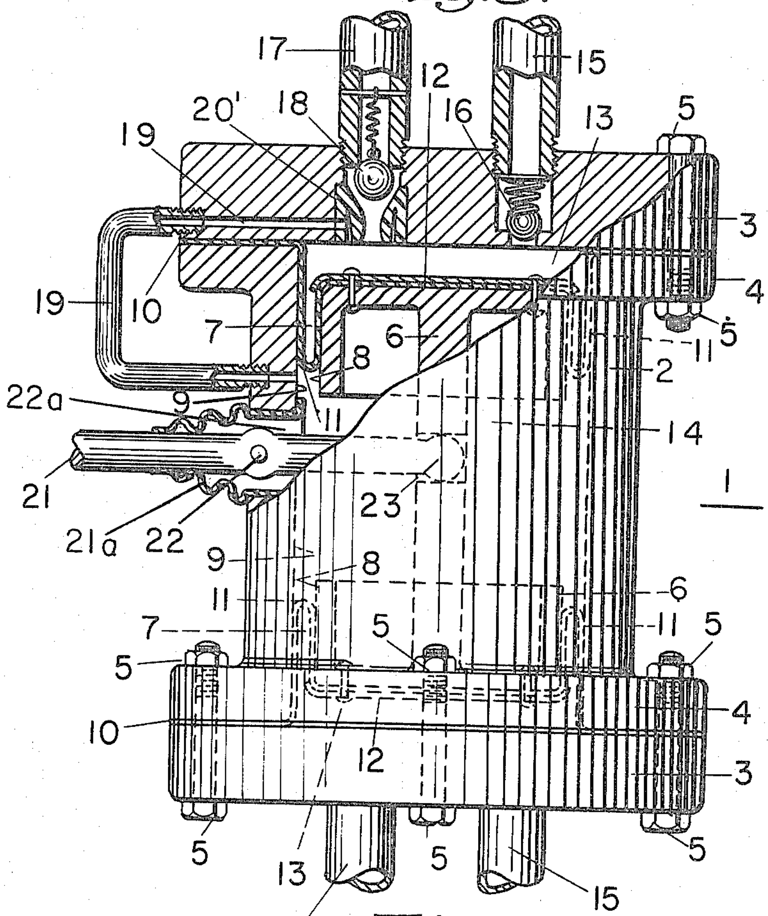
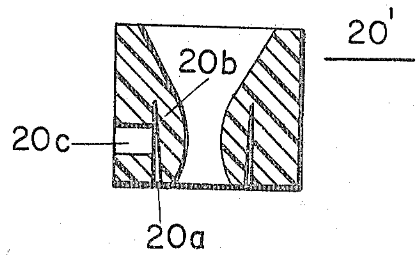


Fig. 4.



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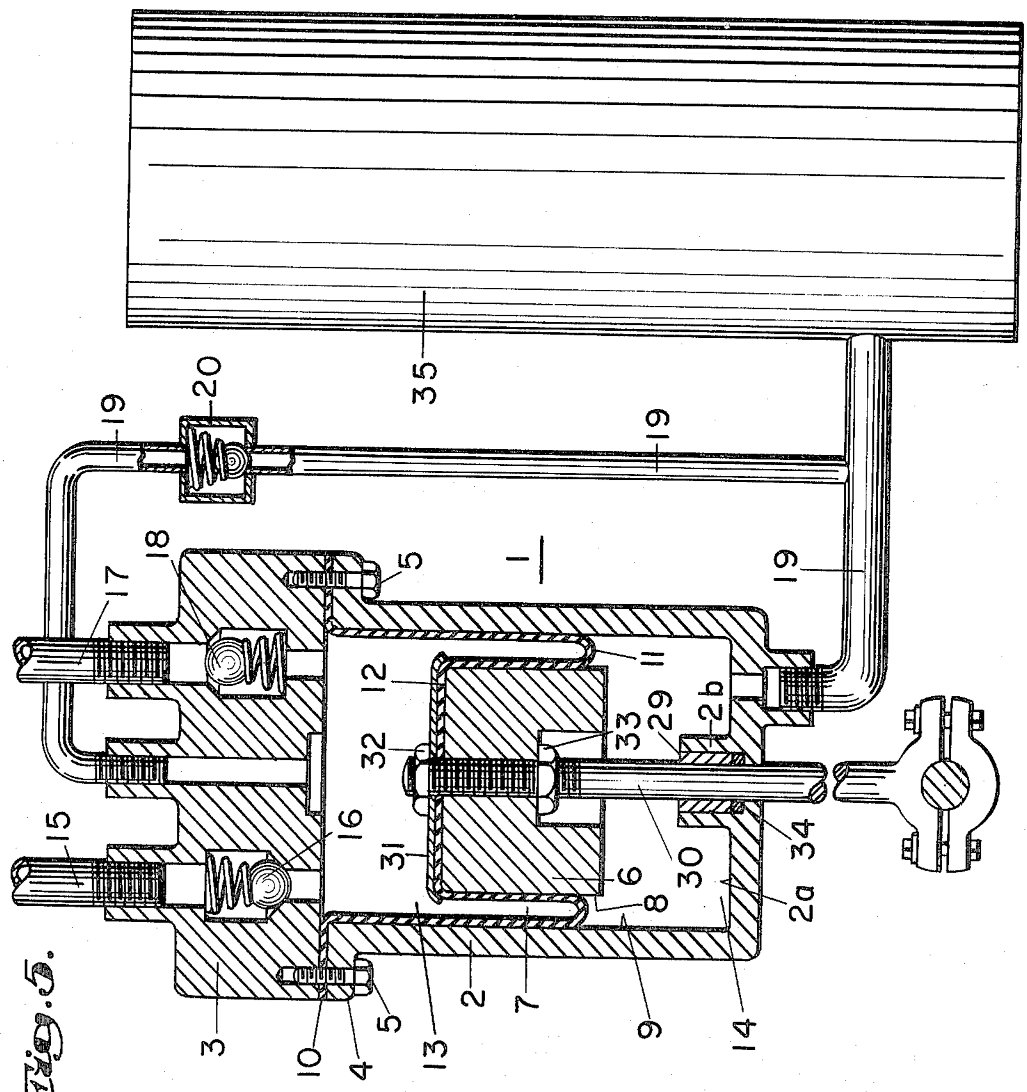

Fig. 5.

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3,208,394
PISTON PUMP HAVING ROLLING DIAPHRAGM AND PRESSURE EQUALIZATION MEANS
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7 Claims. (Cl. 103—150)

This application is a continuation-in-part of my copending patent application Ser. No. 341,889, filed February 3, 1964, for Piston Pump Having Rolling Diaphragm, disclosing means for precluding pressure reversal. The present invention is concerned with means other than those disclosed in my aforementioned patent application for achieving the same end.

This invention relates to piston pumps having rolling diaphragms.

The rolling diaphragms of such piston pumps have a radially outer fixed flange portion clamped to the cylinder of the pump and a radially inner flange portion which is secured to the top of the piston of the pump. The rolling diaphragm further includes an intermediate portion known as the rolling wall thereof. During the suction stroke of the piston pump the rolling wall of the diaphragm rolls off the piston wall onto the cylinder side wall. Thereafter during the compression stroke of the piston pump the rolling wall performs a reverse movement, i.e., it rolls off the side wall of the cylinder onto the side wall of the piston. The rolling diaphragm of such a piston pump subdivides the cylinder into two chambers. One of these two chambers is the pump chamber into which a gas or liquid is sucked during the suction stroke of the piston pump, and out of which the gas or liquid is pressed during the following compression stroke of the piston of the pump. The other of the two chambers into which the cylinder is subdivided by the rolling diaphragm may be referred to as the inactive chamber since the gas or liquid to be moved by the pump never enters into that chamber.

In order for a piston pump having a rolling diaphragm to properly perform the pressure in the pump chamber must always exceed the pressure in the inactive chamber. The term pressure reversal refers to a condition wherein the pressure in the inactive chamber exceeds the pressure in the pump chamber. Pressure reversal may result in a collapse of the rolling diaphragm which, in turn, renders the pump inoperative.

It is, therefore, a principal object of this invention to provide reciprocating piston pumps having rolling diaphragms which pumps are not subject to pressure reversal and to collapse of their diaphragm.

In a piston pump having a rolling diaphragm wherein the inactive chamber is freely vented the degree of pressure-build-up in the inactive chamber depends upon the size of the latter, the velocity of the reciprocating movement of the piston, the area of the venting or air dumping orifice, etc. One or more of these parameters may unavoidably be such as to establish a tendency of pressure reversal and collapse of the rolling diaphragm.

It is, therefore, another object of the invention to provide piston pumps having rolling diaphragms which pumps depart from the heretofore adhered-to principle of freely venting the inactive chamber to atmosphere, and wherein safer and more effective means are used for precluding pressure reversal and collapse of the rolling diaphragm.

The foregoing and other general and special objects of the invention and advantages thereof will more clearly appear from the following description of the invention as illustrated in the accompanying drawings wherein:

FIG. 1 is in part a vertical section and in part a side elevation of a tandem piston pump embodying this invention;

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FIG. 2 is in part a vertical section and in part a side elevation of another tandem piston pump embodying this invention;

FIG. 3 is in part a vertical section and in part a side elevation of still another tandem piston pump embodying this invention;

FIG. 4 is a vertical section of a detail of the structure of FIG. 3; and

FIG. 5 is substantially a vertical section of a piston pump embodying this invention having a single piston rather than a pair of tandem pistons.

The same reference characters have been applied in all the figures to designate like parts.

Referring now to the drawings, and more particularly to FIG. 1 thereof, numeral 1 has been applied to generally indicate a cylinder body including a central portion 2 and two axially outer portions 3. Central portion 2 is provided with flanges 4, and the axially outer portions 3 are clamped against flanges 4 by screws 5. The central portion 2 of cylinder body 1 accommodates an integral pair of reciprocating tandem pistons 6. Each piston 6 defines a gap 7 between the radially outer lateral cylindrical surface 8 thereof and the radially inner lateral cylindrical surface 9 of portion 2 of cylinder body 1. The pump comprises further a pair of rolling diaphragms. Each rolling diaphragm includes a radially outer flange portion 10 clamped between parts 3 and 4, a rolling wall 11 arranged inside of gap 7 and a radially inner flange portion 12 secured to an end surface of a piston 6. Rolling diaphragms 10, 11, 12 subdivide the inside of cylinder body 1 into a pair of axially outer pump chambers 13 and an axially inner inactive chamber 14. Each axially outer portion 3 of cylinder body 1 defines a compression outlet 15 controlled by a spring-biased check valve 16 and a suction inlet 17 controlled by a spring-biased check valve 18. (The check valves in the lower inlet 17 and the lower outlet 15 are not shown in the drawings.) A duct or passage 19 including check valve 20 connects the upper pump chamber 13 and the inactive chamber 14. Check valve 20 is arranged in such a way in duct or passageway 19 as to allow the flow of gas from inactive chamber to the upper pump chamber 13 and to preclude the flow of gas in opposite or reverse direction.

Pistons 6 may be operated or reciprocated by means of drive lever 21 fulcrumed at 22 on cylinder body 1 and pivotally connected to the tandem piston unit 6, 6 at 23. Bellows 25 seals lateral opening 22*a* in cylinder body 1 provided therein for the passage of drive lever 21.

When tandem pistons 6, 6 are moved downwardly a partial vacuum is established in the upper pump chamber 13 and the fluid contained in the lower pump chamber 13 is compressed. As a result of the partial vacuum established in the upper pump chamber 13 gas is sucked into the latter through upper suction inlet 17 and check valve 18 and also through duct or passageway 19 and check valve 20. As a result of the flow of gas through suction inlet 15 gas is admitted to upper pump chamber 13 and as a result of the flow of gas through parts 19 and 20 inactive chamber 14 is evacuated. Each suction stroke of the upper piston 6 results in progressive evacuation of inactive chamber 16. Thus the pressure in inactive chamber 14 is maintained sufficiently low, or substantially equal to, the pressure prevailing in the pump chamber 13 during the suction stroke. Since there is a small pressure drop along passageway or duct 19 the pressure in the upper pump chamber 13 may be slightly less than the pressure in the inactive chamber 14 during the suction stroke of the upper piston 6. There is thus a substantial though not a complete equilization of pressure in the upper pump chamber 13 and the inactive chamber 14. The degree of equalization of pressure in upper pump chamber 13 and inactive chamber 14 is, however, sufficient to safely preclude any collapse of the upper rolling diaphragm.

While the upper piston 6 performs its suction stroke the lower piston 6 performs its compression stroke resulting in movement of gas under pressure from lower pump chamber 13 through lower outlet duct 15 and the check valve which is associated with it. During the compression stroke of the lower piston 6 the pressure prevailing in the lower pump chamber 13 is far above the pressure prevailing in the inactive chamber 14, and therefore there is no danger of any collapse of the lower rolling diaphragm 10, 11, 12.

During the subsequent upward movement of tandem pistons 6, 6 the gas in the upper pump chamber 13 is compressed and expelled through upper outlet 15 and check valve 16 and a partial vacuum is established in the lower pump chamber 13 resulting in an inflow of gas through lower passageway 17 and the check valve which is associated with it. The excess of pressure then prevailing in lower pump chamber 13 over that prevailing in inactive chamber 14 is so slight as not to involve any danger of a collapse of the lower rolling diaphragm 10, 11, 12.

If desired, the pump may be provided with a second evacuation duct (not shown) similar to duct 19 and connecting the lower pump chamber 13 and the inactive chamber 14. Such a duct must include a check valve similar to check valve 20 allowing the flow of gas from inactive chamber 14 into the lower pump chamber 13 and precluding any flow of gas in the reverse direction.

The structure of FIG. 2 is substantially identical to that of FIG. 1 and, therefore, requires description only to the extent that it differs from that of FIG. 1. As shown in FIG. 2 the upper piston 6 is provided with an upper check valve 20*a*, and the lower piston 6 is provided with a lower check valve 20*b*. The upper check valve 20*a* allows venting and evacuation of inactive chamber 14 into the upper pump chamber 13 during the suction stroke of the upper piston 6. The lower check valve 20*b* allows venting and evacuation of inactive chamber 14 into the lower pump chamber 13 during the suction stroke of the lower piston 6. The upper and lower check valves 20*a*, 20*b* preclude any flow of gas from pump chambers 13 into inactive chamber 14. As a result, the highest pressure inside of inactive chamber 14 will be substantially equal to, or but insignificantly higher than, the lowest pressure prevailing in pump chambers 13 during the suction strokes of tandem pistons 6, 6. This effectively precludes collapse of either of the two rolling diaphragms 10, 11, 12.

The structure of FIG. 2 is fully operative and effective with but one of the check valves 20*a*, 20*b* present. The second check valve is more or less a standby or safety feature and its presence is, therefore, optional rather than mandatory.

The structure of FIG. 3 is substantially identical to that of FIG. 1 and, therefore, requires description only to the extent that it differs from that of FIG. 1. As shown in FIG. 3 the suction inlet 17 includes a venturi tube or venturi passage 20′ establishing a zone of relatively low fluid pressure and relatively high fluid velocity. Duct means 19 connect said low pressure zone of venturi passage 20′ to inactive chamber 14. Duct means 19 are controlled by any desired kind of check valve allowing fluid flow from inactive chamber 14 to the low pressure zone of venturi passage 20′ and precluding fluid flow from venturi passage 20′ to inactive chamber 14. In the structure of FIG. 3 venturi passage 20′ and the aforementioned check valve are formed by an integral or unitary structure, i.e. venturi passage 20′ includes a hinged flap check valve.

As best shown in FIG 4 venturi passage 20′ made of an elastomer is provided with a substantially cylindrical slit 20*a* forming a substantially toroidal hinged flap 20*b*. Conduit 20*c* branches off venturi passage 20′ and communicates with cylindrical slit 20*a*. Conduit 20*c* forms a part of passageway 19 connected to inactive chamber 14.

During the downward or suction stroke of upper piston 6 a high fluid velocity and low fluid pressure zone is established where the venturi passage 20′ narrows down and establishes a zone of minimal cross-section. As a result of the formation of this low pressure zone hinged flap 20*b* moves radially inwardly, thus exposing conduit 20*c*. Therefore a flow of fluid is established from inactive chamber 14 to the low pressure zone of venturi passage 20′. This results in an effective evacuation of inactive chamber 14. During the compression stroke of upper piston 6 the pressure inside of venturi tube 20 is relatively high. As a result, hinged flap 20*b* swings radially outwardly and seals passageway 19, thus precluding the flow of fluid from upper pump chamber 13 into inactive chamber 14.

Referring now to FIG. 5 of the drawings, numeral 1 has been applied to generally indicate a cylinder body comprising an upper cylinder body portion 3 and a lower cylinder body portion 2 held together by screws 5. The aforementioned cylinder body portions 2, 3 may be formed, for instance, of aluminum castings. The upper portion 3 of the cylinder body 1 defines a suction inlet 17 including a spring biased inlet check valve 18 and a pressure outlet 15 including a spring biased outlet check valve 16. Reciprocating piston 6 is arranged inside of cylinder body 1 and has a top surface and a bottom surface. The lower portion 2 of cylinder body 1 defines an internal bottom surface 2*a* which includes an upstanding collar 2*b* arranged in coaxial relation to, and inside of, cylinder body 1. Collar 2*b* accommodates a slide bearing 29 guiding a piston rod 30 secured to piston 6. The bottom surface of piston 6 has a cylindrical recess adapted to receive collar 2*b* when piston 6 is in its lowest position, i.e. is completing the suction stroke thereof. Speaking more generally, the bottom surface of piston 6 is shaped to conform substantially with the internal bottom surface 2*a* of cylinder body 1. Reference numerals 10, 11, 12 have been applied to indicate a rolling diaphragm made of a woven fabric impregnated with an appropriate elastomer. The rolling diaphragm includes a radially outer flange portion 10 clamped between portions 2, 3 of cylinder body 1, an intermediate rolling wall 11 arranged in gap 7, and a radially inner flange portion 12 secured to the top surface of piston 6. To this end the radially inner flange portion 12 of the rolling diaphragm 10, 11, 12 is covered by a clamping plate 31 screwed against the top surface of piston 6 by means of nut 32 riding on the screw-threaded top end of piston rod 30. Screw-nut 33 is arranged inside of the center recess of piston 6 and clamps the latter against the radially inner portion 12 of the rolling diaphragm 10, 11, 12 and against clamping plate 31. Rolling diaphragm 10, 11, 12 subdivides the interior of cylinder body 1 into the upper pump chamber 13 and a lower chamber 14 referred to as the inactive chamber. Ducts 19 connect inactive chamber 14 with pump chamber 13. Check valve 20 precludes flow of gas from pump chamber 13 to inactive chamber 14 but allows the flow of gas in reverse direction. The lower portion 2 of cylinder body 1 is provided with a circular groove receiving a so-called O-ring 34, or an equivalent annular elastic seal surrounding piston rod 30. Seal 21 limits the inflow of air into inactive chamber 14 and thus makes it possible to maintain therein a pressure less than atmospheric pressure. Reference numeral 35 has been applied to indicate a surge tank connected to inactive chamber 14.

When piston 6 is moved downward by motor means (not shown in FIG. 5) operating piston rod 30, i.e. during the suction stroke of piston 6, gas enters through suction inlet 17 and check valve 18 into pump chamber 13. Upon reversal of the motion of piston 6, i.e. during the compression stroke thereof, gas contained in pump chamber 13 is expelled through outlet 15 and check valve 16. During each suction stroke of the pump a gas flow is established from inactive chamber 14 through ducts 19 and check valve 20 to pump chamber 13. Surge tank 35 is a partially evacuated space whose volume is large in comparison to that of the internal volume of cylinder body **1**. As a result, the pressure in inactive chamber **14** tends to be equal to that prevailing inside of surge tank **35**. Surge tank **35** may be connected to some other pump tending to maintain therein a predetermined pressure, less than atmospheric pressure.

While, in accordance with the patent statutes, I have disclosed the specific details of several embodiments of my invention, it is to be understood that these details are merely illustrative and that many variations thereof may be made without departing from the spirit and scope of the invention. It is therefore, my desire that the language of the accompanying claims shall be accorded the broadest reasonable construction, and shall be limited only by what is expressly stated therein, and by the prior art.

I claim as my invention:

1. A piston pump comprising in combination:
(a) a cylinder body having a suction inlet and a compression outlet;
(b) a reciprocating piston inside said cylinder body defining a gap between the radially inner surface of said cylinder body and the radially outer surface of said piston;
(c) a rolling diaphragm having a radially outer portion secured to said cylinder body, a radially inner portion secured to said piston and a rolling wall between said radially outer portion and said radially inner portion arranged inside of said gap, said rolling diaphragm subdividing said cylinder body into a pump chamber and an inactive chamber;
(d) duct means connnecting to said inactive chamber a point of said pump where the pressure drops below atmospheric pressure; and
(e) a check valve arranged in said duct means to allow fluid flow from said inactive chamber to said point of said pump and to preclude fluid flow from said point of said pump to said inactive chamber.

2. A piston pump comprising in combination:
(a) a cylinder body having a suction inlet and a compression outlet;
(b) a reciprocating piston inside said cylinder body defining a gap between the radially inner surface of said cylinder body and the radially outer surface of said piston;
(c) a rolling diaphragm having a radially outer portion secured to said cylinder body, a radially inner portion secured to said piston and a rolling wall between said radially outer portion and said radially inner portion arranged inside of said gap, said rolling diaphragm subdividing said cylinder body into a pump chamber and an inactive chamber;
(d) duct means connecting said pump chamber and said inactive chamber; and
(e) a check valve arranged in said duct means to allow fluid flow from said inactive chamber to said pump chamber and to preclude fluid flow from said pump chamber into said inactive chamber.

3. A piston pump comprising in combination:
(a) a cylinder body having a suction inlet and a compression outlet;
(b) a reciprocating piston inside said cylinder body, said piston having an end surface and defining a gap between the radially outer lateral surface thereof and the radially inner surface of said cylinder body, said piston further defining a passage interconnecting the space situated to one side of said end surface to the space situated to the other side of said end surface;
(c) a rolling diaphragm having a radially outer portion secured to said cylinder body, a radially inner portion secured to said piston and a rolling wall between said radially outer portion and said radially inner portion arranged inside of said gap, said rolling diaphragm subdividing said cylinder body into a pump chamber and an inactive chamber; and

(d) a check valve arranged in said passage to allow fluid flow from said inactive chamber into said pump chamber and to preclude fluid flow from said pump chamber into said inactive chamber.

4. A piston pump comprising in combination:
(a) a cylinder body having a suction inlet and a compression outlet;
(b) a reciprocating piston inside said cylinder body defining a gap between the radially inner surface of said cylinder body and the radially outer surface of said piston;
(c) a rolling diaphragm having a radially outer portion secured to said cylinder body, a radially inner portion secured to said piston and a rolling wall between said radially outer portion and said radially inner portion arranged inside of said gap, said rolling diaphragm subdividing said cylinder body into a pump chamber and an inactive chamber;
(d) duct means situated outside of said cylinder body connecting said pump chamber and said inactive chamber by by-passing said rolling diaphragm; and
(e) a check valve arranged in said duct means to allow fluid flow from said inactive chamber to said pump chamber and to preclude fluid flow from said pump chamber into said inactive chamber.

5. A piston pump comprising in combination:
(a) a cylinder body having a suction inlet at each end surface thereof and having a compression outlet at each end surface thereof;
(b) an integrated pair of reciprocating tendem pistons inside said cylinder body, each of said pair of pistons defining a gap between the radially outer lateral surface thereof and the radially inner surface of said cylinder body;
(c) a pair of rolling diaphragms each having a radially outer portion secured to said cylinder body, a radially inner portion secured to one of said pair of pistons and a rolling wall intermediate said radially outer portion and said radially inner portion arranged inside said gap defined by one of said pair of pistons, said pair of diaphragms subdividing said cylinder body into a pair of axially outer pump chambers and into an axially inner inactive chamber;
(d) a pair of duct means each connecting one of said pair of pump chambers and said inactive chamber; and
(e) a pair of check valves each arranged in one of said pair of duct means to allow fluid flow from said pair of pump chambers to said inactive chamber and to preclude the flow of fluid from said pair of pump chambers to said inactive chamber.

6. A piston pump comprising in combination:
(a) a cylinder body having a suction inlet and a compression outlet;
(b) a venturi passage establishing a zone of relatively low fluid pressure and relatively high fluid velocity forming part of said suction inlet;
(c) a reciprocating piston inside said cylinder body defining a gap between the radially inner surface of said cylinder body and the radially outer surface of said piston;
(d) a rolling diaphragm having a radially outer portion secured to said cylinder body, a radially inner portion secured to said piston and a rolling wall between said radially outer portion and said radially inner portion arranged inside of said gap, said rolling diaphragm subdividing said cylinder body into a pump chamber and an inactive chamber;
(e) duct means connecting said low pressure zone of said venturi passage to said inactive chamber; and
(f) a check valve arranged in said duct means to allow fluid flow from said inactive chamber to said venturi passage and to preclude fluid flow from said venturi passage to said inactive chamber.

7. A piston pump comprising in combination:

(a) a cylinder body having a suction inlet and a compression outlet;

(b) a venturi passage establishing a zone of relatively low fluid pressure and relatively high fluid velocity forming part of said suction inlet, said venturi passage including means defining a conduit branching off said venturi passage and a hinged flap check valve precluding fluid flow through said branch conduit to said venturi passage;

(c) a reciprocating piston inside said cylinder body defining a gap between the radially inner surface of said cylinder body and the radially outer surface of said piston;

(d) a rolling diaphragm having a radially outer portion secured to said cylinder body, a radially inner

portion secured to said piston and a rolling wall between said radially outer portion and said radially inner portion arranged inside of said gap, said rolling diaphragm subdividing said cylinder body into a pump chamber and an inactive chamber; and

(e) duct means connecting said conduit and said inactive chamber.

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